

## REMARKS

Applicants have canceled claims 58, 61 and 62 without prejudice to introduction in a subsequent application or reintroduction in the present application. The cancellation of claims 58, 61 and 62 renders their rejection herein moot. Applicants have also added new claim 109. Support for new claim 109 is found in paragraphs [180] and [195] as well as elsewhere throughout the specification of the published application (US 2005/0129947). Additional support is found in the originally filed claims. As a result, claims 59, 60, 63-68 and 109 are pending in the application with claims 1-57, 69-98, and 100-108 being withdrawn in view of the Restriction Requirement mailed September 26, 2006.

Claims 58-68 are rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. Claims 58-68 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Claims 58-68 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Reiss et al., *Nano Letters*, 2, (7), 781-784 (2002) (hereinafter "Reiss") in view of United States Patent 4,675,207 to Nicolau (hereinafter "Nicolau"). Claims 58-68 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Reiss in view of Nicolau and further in view of Li et al., *Journal of the American Chemical Society* (9/23/2003, volume 125, pages 12567-12575) (hereinafter "Li"). Claims 58-68 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Reiss in view of United States Patent 5,300,793 to Kondow et al. (hereinafter "Kondow") and Nicolau.

Applicant respectfully requests reconsideration of the present application in view of the foregoing Amendment and following Remarks.

### Claims 58-68 and 35 U.S.C. § 112, First Paragraph

Claims 58-68 are rejected under 35 U.S.C. § 112, first paragraph, for failing to comply with the written description requirement. Specifically, the Examiner states that the recitation "resulting in a mixture comprising the solution of core nanocrystals, the cation precursor solution and the anion precursor solution" in claims 58 and 59 is not described in the specification in such a way as to reasonably convey to one of skill in the

art that the inventors, at the time the application was filed, had possession of the claimed invention.

While respectfully disagreeing with the Examiner, Applicants have amended claim 59 to remove the forgoing recitation. In view of the amendment, Applicants respectfully request that the present rejection be withdrawn.

Claims 58-68 and 35 U.S.C. § 112, Second Paragraph

Claims 58-68 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Specifically, the Examiner states:

Language of claims 58 and 59 stays confusing because it is not clear how after covering the core nanocrystals with a monolayer of cation, the core nanocrystals are still present by the time of adding the anion precursor.<sup>1</sup>

While respectfully disagreeing with the Examiner, Applicants have amended claim 59 to indicate the presence of the cation monolayer at the time of anion precursor addition. In view of the forgoing amendment, Applicants respectfully assert that the present claims are definite and respectfully request that the present rejection be withdrawn.

Claims 58-68 and 35 U.S.C. § 103(a)

The rejection of claims 58-68 under 35 U.S.C. § 103(a) as being unpatentable over Reiss in view of Nicolau is respectfully traversed.

Applicants have amended claim 59 to recite that the cation ( $M^2$ ) precursor solution and the anion precursor solution ( $X^2$ ) are added to the reaction vessel used in the synthesis of core/shell nanocrystals in an alternating manner. Support for the present amendment to claim 59 is found in Examples 4, 5, 12, 13, 15, 16, 17, 18 and 19 as well as elsewhere throughout the specification of the present application. The foregoing Examples each disclose placing a solution of core nanocrystals in a reaction vessel (e.g.

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<sup>1</sup> Final Office Action mailed December 19, 2008, page 3.

3-neck flask) and adding to the vessel, in an alternating manner, the cation precursor solution and the anion precursor solution. Example 16, for example, recites:

A sample of CdS core nanocrystals of a known size and concentration was used to prepare a CdS reaction solution containing ODE as the solvent and octadecylamine (ODA) as the ligand. A typical reaction contained  $5 \times 10^{-8}$  mol of CdS, however, the concentration did not need to be fixed as long as the precursor injections were enough to create a single monolayer on the surface of the cores. Once the CdS, 5 grams of ODE, and 1 gram of ODA were added to the reaction flask, the reaction was heated up to 100°C while under vacuum. When the reaction stopped bubbling, the solution was placed under argon flow and heated up to 180°C for InP shell growth. The indium-Oleic acid and tris(trimethylsilylphosphine) precursors in ODE (0.04 M each) were added in alternating injections at 180°C.

To establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). The combination of Reiss and Nicolau does not teach all the limitations of claim 59.

As recognized by the Examiner, Reiss discloses a one-step method for the production of core/shell nanocrystals wherein the cation precursor and the anion precursor solutions are simultaneously added to a solution of core nanocrystals. Reiss, for example, recites:

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Consequently, ZnO (cation precursor) was complexed with dodecylphosphonic acid and slowly injected *together* with TOPSe (anion precursor) into a mixture of HAD/TOPO containing CdSe core nanocrystals.<sup>2</sup> (*Emphasis added*)

By describing the simultaneous addition of cation precursor solution and anion precursor solution, Reiss fails to teach the limitations of claim 59, wherein the cation precursor solution and anion precursor solution are added to the reaction vessel in an alternating manner.

Moreover, Nicolau also fails to teach the limitations of claim 59, wherein the cation precursor solution and the anion precursor solution are added to the same reaction

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<sup>2</sup> Reiss, page 782.

vessel in an alternating manner. Nicolau discloses a method of immersing a unitary substrate in independent salt solutions with rinsing between immersions. Nicolau, for example, recites:

The present invention therefore specifically relates to a process for the deposition on a substrate of a thin film of a compound containing at least one cationic constituent C and at least one anionic constituent A, wherein it comprises forming on said substrate at least two superimposed ionic layers respectively containing the cationic constituent or constituents C and the anionic constituent or constituents A by successive immersions of the substrate in at least one first solution containing at least one salt, a complex or an ionized compound of said cationic constituent or constituents C or a precursor of said cationic constituent or constituents C, and at least one second solution containing at least one salt, a complex or an ionized compound of said anionic constituent or constituents A or a precursor of said anionic constituent or constituents A, said substrate undergoing rinsing by a solvent between two immersions.<sup>3</sup> [Emphasis added]

The separate and independent cation and anion precursor solutions of Nicolau fail to teach or suggest the limitations of claim 59 wherein cation precursor solution and anion precursor solution are added to the same reaction vessel in the production of core/shell nanocrystals.

Nicolau actually teaches away from adding cation precursor solution and anion precursor solution into the same reaction vessel in the production of core/shell nanocrystals. As provided above, Nicolau teaches separation of the cation precursor solution from the anion precursor solution by requiring independent solutions of cation precursor and anion precursor. Nicolau additionally requires that the substrate be rinsed between immersions in the separate cation and anion precursor solutions. Nicolau recites:

Following the first immersion, the excess solution adhering to the substrate is eliminated during rinsing by convection and diffusion...The rinsing time is such that there is a complete elimination by convection and diffusion of the excess solution adhering to the substrate.<sup>4</sup> [Emphasis added]

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<sup>3</sup> Nicolau, Column 2, line 57 through Column 3, line 5.

<sup>4</sup> Nicolau, Column 3, lines 20-23 and Column 5, lines 9-12.

As described by Nicolau, the required rinsing step is critical to the deposition of a compound of type  $C_mA_n$  on the substrate. According to Nicolau, if excess cation precursor solution and/or excess anion precursor solution is not rinsed from the substrate, precipitation of the compound  $C_mA_n$  will occur in the solvent diffusion layer as opposed to the substrate-solution interface. Nicolau, for example, recites:

In this process, the growth of the thin film of the compound take place by heterogeneous chemical reaction at the substrate-solution interface between cations C and anions A adsorbed on the substrate. Thus, on immersing the substrate in the first solution, which e.g. contains an ionized salt of the cationic constituent C, there forms on the substrate a double electrical layer of the Helmholtz type comprising a cationic layer of the cationic constituent C and an anionic layer of the anion of the salt present in the first solution.

Following this first immersion, the excess solution adhering to the substrate is eliminated during rinsing by convection and diffusion. On then immersing the substrate in the second solution, the anionic constituent A and the cation associated therewith in the second solution pass through the limit solvent layer adhering to the substrate and penetrate the Helmholtz layer. At this moment there are exchanges in the Helmholtz layer, whereof the structure changes by reaction between the cationic constituents C and the anionic constituent A which have been adsorbed, the anionic constituents discharge and the thus adsorbed atoms which have just reacted diffuse at the surface and give rise to monocrystalline grains occupying their characteristic site in the lattice of the compound.<sup>5</sup>

As described above, the anionic constituent must pass through the limit solvent layer adhering to the substrate and penetrate the Helmholtz layer in order to react with the cationic constituent at the substrate/solvent interface to form a compound  $C_mA_n$ .

As explained by Nicolau, if excess cationic constituent is present in the limit solvent layer as a result of not rinsing the substrate, combination of the excess cation constituent with the anion constituent will occur in the limit solvent layer resulting in precipitation of the compound  $C_mA_n$  in the limit solvent layer.<sup>6</sup> Precipitation in the limit solvent layer precludes the formation of fault free, compact layers of compounds  $C_mA_n$

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<sup>5</sup> Nicolau, Column 3, lines 6-15 and 21-35.

<sup>6</sup> Nicolau, Column 5, lines 28-52.

on the surface of the substrate. For this reason, Nicolau requires the “complete elimination of excess solution adhering to the substrate.”<sup>7</sup>

Rinsing between immersions is fundamentally inconsistent with and teaches away from adding cation precursor solution and anion precursor solution into the same reaction vessel in the production of core/shell nanocrystals. [See, *In re Gurley*, 27 F.3d 551, 31 USPQ2d 1130 (Fed. Cir. 1994), holding “we have noted...as a useful general rule, that references that teach away cannot serve to create a prima facie case of obviousness...A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant.”]

Furthermore, the combination of Reiss and Nicolau is improper according to Office examination guidelines and well established Federal Circuit case law. By requiring separate immersions and rinsing between the immersions, Nicolau is inherently incompatible with and teaches away from Reiss. As provided herein, Reiss requires the simultaneous addition of cation precursor and anion precursor to the same reaction vessel. As a result of this incompatibility and teaching away, Nicolau and Reiss cannot be properly combined. See, *In re Grasselli*, 713 F.2d 731, 218 USPQ 769 (Fed. Cir. 1983); MPEP § 2145, XD2 (It is improper to combine references where the references teach away from their combination)

In view of the foregoing, the combination of Reiss and Nicolau is improper. However, even if the combination of Reiss and Nicolau were proper, the combination does not teach or suggest each limitation of claim 59. Furthermore, Reiss and Nicolau, alone and in combination, teach away from methods of the present invention wherein cation precursor solution and anion precursor solution are added to the same reaction vessel in an alternating manner. As a result, a prima facie case of obviousness to support a rejection of pending claims 59, 60 and 63-68 under 35 U.S.C. § 103(a) has not been established. Applicant respectfully requests that the present rejection be withdrawn.

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<sup>7</sup> Nicolau, Column 3, lines 20-23 and Column 5, lines 9-12.

Claims 58-68 and 35 U.S.C. § 103(a)

The rejection of claims 58-68 under 35 U.S.C. § 103(a) as being unpatentable over Reiss in view of Nicolau and further in view of Li is respectfully traversed.

For reasons consistent with those presented in the discussion above, Applicants respectfully assert that the combination of Reiss and Nicolau does not teach or suggest a method of producing core/shell nanocrystals wherein the cation precursor solution and the anion precursor solution are added to the same reaction vessel in an alternating manner. The combination of Reiss and Nicolau actually teaches away from the presently claimed methods by requiring separation of the cation and anion precursor solutions and by requiring rinsing between immersions of the substrate in the cation and anion precursor solutions.

Moreover, Li fails to cure the deficiencies of Reiss and Nicolau. The Examiner cites Li to establish the state of the art regarding atomic layer epitaxy (ALE) using molecular beams of cationic and anionic species. Specifically, the Office Action states:

However, Li et al. admitted in the Introduction that it is known in the core/shell nanocrystal art that switching molecular beams of cationic and anionic species on and off in a method of ALE prevents cationic and anionic species to coexist so that local nucleation on the substrate or in the gas phase is avoided.<sup>8</sup>

As recognized by the Examiner in the foregoing recitation, Li also stresses the importance of keeping cation precursor separate from anion precursor. Vapor phase epitaxial techniques, such as those described in Li, purge the reaction chamber between introductions of cationic and anionic species to preclude their coexistence in the vapor phase. Purging the reaction chamber is equivalent to the rinsing step set forth in Nicolau. As a result, Li also teaches away from the presently claimed methods wherein cation precursor solution and anion precursor solution are added to the same reaction vessel without rinsing between additions.

In view of the foregoing, a prima facie case of obviousness to support a rejection of pending claims 59, 60 and 63-68 under 35 U.S.C. § 103(a) has not been established. Appellant respectfully requests that the present rejection be withdrawn.

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<sup>8</sup> Office Action mailed April 22, 2008, page 7.

Claims 58-68 and 35 U.S.C. § 103(a)

The rejection of claims 58-68 under 35 U.S.C. § 103(a) as being unpatentable over Reiss in view of Kondow and Nicolau is respectfully traversed.

For reasons consistent with those presented in the discussion above, Applicants respectfully assert that the combination of Reiss and Nicolau does not teach or suggest a method of producing core/shell nanocrystals wherein the cation precursor solution and the anion precursor solution are added to the same reaction vessel in an alternating manner. The combination of Reiss and Nicolau actually teaches away from the presently claimed methods by requiring separation of the cation and anion precursor solution and by requiring rinsing between immersions of the substrate in the cation and anion precursor solutions.

Moreover, Kondow fails to cure the deficiencies of Reiss and Nicolau. As with Nicolau, Kondow explicitly recognizes the importance of keeping cation precursor separate from anion precursor in solution phase epitaxial techniques. Kondow, for example, recites:

The liquid phase epitaxial growth technique which is most prevalently used at present has a growth speed as fast as 1000 Å/sec. Therefore, a large amount of anion atoms and cation atoms are simultaneously supplied to the growing surface. Thus, the probability that the supplied anion atoms and cation atoms are bonded with each other is much higher than the probability that the supplied cation atoms (or anion atoms) are bonded to the anion atoms (or cation atoms) on the growing surface, thus making it impossible to realize intended epitaxial growth.<sup>9</sup>

In view of this recitation, Kondow teaches away from methods of the present invention wherein cation precursor solution and anion precursor solution are added to the same reaction vessel without rinsing between additions.

Additionally, Kondow provides no teaching or suggestion that supersedes Nicolau's explicit requirement of rinsing between alternate immersions in cation precursor solution and anion precursor solution in order to obtain fault-free, compact layers of compounds of formula  $C_mA_n$ . Kondow only description of liquid phase epitaxial techniques is provided in the recitation above.

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<sup>9</sup> Kondow, Column 3, lines 56-66.



In view of the foregoing, a prima facie case of obviousness to support a rejection of pending claims 59, 60 and 63-68 under 35 U.S.C. § 103(a) has not been established. Appellant respectfully requests that the present rejection be withdrawn.

New Claim 109

Applicants have added new claim 109. Support for new claim 109 is provided above. Applicants respectfully assert new claim 109 is patentable over the prior art of record in the application for reasons consistent with those presented herein.


CONCLUSION

In view of the foregoing, a favorable Office Action is respectfully solicited. The Examiner is respectfully invited to contact J. Clinton Wimbish at 704.338.5021 to discuss any matter related to the present application.

Respectfully submitted,

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Date

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